U. S. DEPARTMENT OF COMMERCE

BUILDING MATERIALS AND STRUCTURES

REPORT BMS42

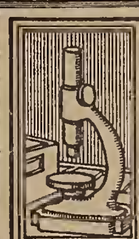
Structural Properties of Wood-Frame Wall and Partition Constructions With "Celotex" Insulating Boards

Sponsored by
The Celotex Corporation

by

HERBERT L. WHITTEMORE
and AMBROSE H. STANG
with the collaboration of
THOMAS R. C. WILSON
Forest Products Laboratory

NATIONAL
BUREAU OF STANDARDS



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ISSUED MARCH 2, 1940

The National Bureau of Standards is a fact-finding organization; it does not "approve" any particular material or method of construction. The technical findings in this series of reports are to be construed accordingly.

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Foreword

This report is one of a series issued by the National Bureau of Standards on the structural properties of constructions intended for low-cost houses and apartments. These constructions were sponsored by organizations within the building industry advocating and promoting their use. The sponsor built and submitted the specimens described in this report for participation in the program outlined in BMS2, Methods of Determining the Structural Properties of Low-Cost House Constructions. The sponsor, therefore, is responsible for the design of the constructions and the description of materials and methods used in their fabrication. The Bureau is responsible for the method of testing and the test results.

This report covers only the load-deformation relations and strength of the structural elements of a house when subjected to compressive, transverse, concentrated, impact, and racking loads by standardized methods simulating the loads to which the elements would be subjected in actual service. Later it may be feasible to determine the heat transmission at ordinary temperatures and the fire resistance of these same constructions.

The National Bureau of Standards does not "approve" a construction, nor does it express an opinion as to the merits of a construction for the reasons given in reports BMS1 and BMS2. The technical facts presented in this series provide the basic data from which architects and engineers can determine whether a construction meets desired performance requirements.

Lyman J. Briggs, *Director.*

Structural Properties of Wood-Frame Wall and Partition Constructions with "Celotex" Insulating Boards Sponsored by The Celotex Corporation

by HERBERT L. WHITTEMORE *and* AMBROSE H. STANG

with the collaboration of

THOMAS R. C. WILSON, Forest Products Laboratory, Forest Service, United States Department of Agriculture

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ABSTRACT

For the program on the determination of the structural properties of low-cost house constructions, The Celotex Corporation submitted 42 specimens representing 2 wall and 2 partition constructions having wood framing with "Celotex Vapor-seal Insulating" sheathing, "Celotex" building board, and "Celotex Vapor-seal Insulating" lath.

The wall specimens were subjected to compressive, transverse, concentrated, impact, and racking loads and the partition specimens to impact and concentrated loads. The transverse, concentrated, and impact loads were applied to both faces of the wall specimens. The deformation under load and the set after the load was removed were measured for uniform increments of load, except for concentrated loads, for which the set only was determined. The results are presented in graphs and in tables.

I. INTRODUCTION

To provide technical facts on the performance of constructions which might be used in low-cost houses, to discover promising new constructions, and ultimately to determine the properties necessary for acceptable performance in actual service, the National Bureau of Standards has invited the cooperation of the building industry in a program of research on building materials and structures suitable for low-cost houses and apartments. The objectives of this program are described in report BMS1, Research on Building Materials and Structures for Use in Low-Cost Housing, and that part of the program relating to structural properties in report BMS2, Methods of Determining the Structural Properties of Low-Cost House Constructions.

Masonry constructions and wood constructions of types which have been extensively used in this country for houses were included in the program because their behavior under widely different service conditions is known to builders

and the public. The reports on these constructions are BMS5, Structural Properties of Six Masonry Wall Constructions, and BMS25, Structural Properties of Conventional Wood-Frame Constructions for Walls, Partitions, Floors, and Roofs. The masonry specimens were built by the Masonry Construction Section of this Bureau, and the wood-frame specimens were built and tested by the Forest Products Laboratory at Madison, Wis.

The present report describes the structural properties of constructions sponsored by one of the manufacturers in the building industry. The specimens were subjected to compressive, transverse, concentrated, impact, and racking loads, simulating loads to which the elements of a house are subjected. In actual service, compressive loads on a wall are produced by the weight of the roof, second-story walls if any, furniture and occupants, and snow and wind loads on the roof. Transverse loads on a wall are produced by the wind, concentrated and impact loads by furniture or accidental contact with heavy objects, and racking loads by the action of the wind on adjoining walls. For non-load-bearing partitions, impact loads may be applied accidentally by furniture or by a person falling against a partition, and concentrated loads by a ladder or other object leaning against the partition.

The deformation and set under each increment of load were measured because, considered as a structure, the suitability of a wall or partition construction depends not only on its resistance to deformation when loads are applied but also on whether it returns to its original size and shape when the loads are removed.

II. SPONSOR AND PRODUCT

The specimens were submitted by The Celotex Corporation, Chicago, Ill., and represented wood-frame wall and partition constructions with sugarcane-fiber insulating board as sheathing, building board, and lath, marketed under the trade names "Celotex Vapor-seal Insulating" sheathing, "Celotex" building board, and "Celotex Vapor-seal Insulating" lath.

The wood framing was Douglas fir, No. 1 common. The constructions had nominal 2- by 4-in. studs, spaced 1 ft 4 in. on centers, fastened to a single floor plate and to a double top plate. The framing of the partition constructions was similar to that of the wall constructions, except that the top plate was single, not double.

The outside face of the wall constructions was sheathing covered with wood bevel siding. The inside face of the wall constructions and both faces of the partition constructions were either building board or lath and plaster.

III. SPECIMENS AND TESTS

The two wall constructions and the two partition constructions were assigned the symbols given in table 1. The individual specimens were assigned the designations given in table 2.

TABLE 1.—*Construction symbols*

Element	Construction symbol	Outside face	Inside face	Both faces
Wall	*BX*	"Celotex Vapor-seal Insulating" sheathing and wood bevel siding.	"Celotex Vapor-seal Insulating" lath and plaster.	
Do	*BY*	do	"Celotex" building board.	
Partition	*BZ*			"Celotex Vapor-seal Insulating" lath and plaster.
Do	*CA*			"Celotex" building board.

TABLE 2.—*Specimen designations, walls BX and BY, partitions BZ and CA*

Element	Specimen designation	Load	Load applied
Wall	*C1, C2, C3*	Compressive	Upper end.
Do	*T1, T2, T3*	Transverse	Inside face.
Do	*T4, T5, T6*	do	Outside face.
Do	*P1, P2, P3*[a]	Concentrated	Inside face.
Do	*P4, P5, P6*[a]	do	Outside face.
Do	*I1, I2, I3*	Impact	Inside face.
Do	*I4, I5, I6*	do	Outside face.
Do	*R1, R2, R3*	Racking	Top plate.
Partition	*P1, P2, P3*[a]	Concentrated	Either face.
Do	*I1, I2, I3*	Impact	Do.

[a] The concentrated and impact loads were applied to the same specimens. The concentrated loads were applied first.

The specimens were tested in accordance with the procedure outlined in BMS2, Methods of Determining the Structural Properties of Low-Cost House Constructions, which also gives the requirements for the specimens and describes the presentation of the results of the

tests, particularly the load-deformation graphs. Thomas R. C. Wilson, of the Forest Products Laboratory, Madison, Wis., cooperated with the Bureau staff in this work by giving advice and making suggestions on the technique of testing wood structures.

For the compressive test the thickness of the wall was taken as the thickness of the structural portion, that is, the distance from the inside surface of the studs to the outside surface of the studs. The compressive load was applied along a line parallel to the inside face, and at a distance from the inside surface of the studs of one-third the thickness of the wall. For wood-frame constructions under compressive load there is considerable local shortening caused by crushing of the floor plate and the top plate at the ends of the studs. As a result, the shortening of the entire specimen is not proportional to that of a gage length over only part of the height. Therefore the shortenings and sets were measured by means of compressometers attached to the steel plates through which the load was applied to the specimen, not attached to the specimen as described in BMS2.

The deformations under racking load were measured with a right-angle deformeter, consisting of a steel channel and a steel angle braced to form a rigid connection. In use the channel of the deformeter rested along the top of the specimen, with the steel angle extending downward in the plane of the specimen. Two pins passed snugly through holes in the channel into the top of the specimen. Two dial micrometers were attached to a steel block which was in contact with the floor plate of the specimen at the stop. The spindles of the micrometers were in contact with rigid extensions of the steel angle of the deformeter. The gage length (distance from the top of the specimen to the center of the steel block) was 7 ft 11¼ in. The micrometers were graduated to 0.001 in. and readings were recorded to the nearest division. This deformeter was used instead of the taut-wire mirror-scale device described in BMS2.

Before applying the loads, the speed of the movable head of the testing machine was measured under no load. For compressive loading the speed was 0.072 in./min. and for transverse loading 0.14 in./min. These speeds were recommended by the Forest Products Laboratory. Racking loads were applied by means of a jack operated manually, and the speed could not be closely regulated.

Each plastered specimen, *BX* and *BZ*, was tested on the 28th day following the application of the finish coat of plaster.

The tests were begun January 3, 1939, and completed January 13, 1939. A representative of the sponsor witnessed the tests.

IV. MATERIALS

The information for this statement was obtained from the sponsor and from inspection of the specimens. The Forest Products Laboratory assisted by identifying the species of the wood and by supervising the determination of the moisture content. The Paper Section of this Bureau assisted by determining the physical properties of the sheathing, building board, and lath and the Lime and Gypsum Section by determining the properties of the plaster.

1. Wood

Framing.—Studs, floor plates, and top plates, identified as Douglas fir, *Pseudotsuga taxifolia.* No. 1 common, S4S (surfaced four sides), 1⅝ by 3⅝ in. (nominal 2 by 4 in). Weyerhaeuser Timber Co.

Bevel siding.—Identified as southern cypress, *Taxodium distichum.* Select, grade B or better, 7/16 by 3/16 by 5½ in.

Table 3.—*Moisture content of the wood*

[Determined on the day the wall or partition specimen was tested]

Wood	Construction symbol	Moisture content [a]		
		Minimum	Maximum	Average
		Percent	*Percent*	*Percent*
Framing	*BX*	8	16	10
	BY	8	17	13
	BZ	10	14	12
	CA	10	14	11
Average				12
Bevel siding	*BX*	[b] <7	8	
	BY	7	10	8

[a] Based on the weight when oven dry.
[b] "Less than" (<) symbol.

After each specimen was tested, one face was removed to expose the studs, and photographs were taken showing the knots and failures. Typical specimens are shown in figures 1 and 2.

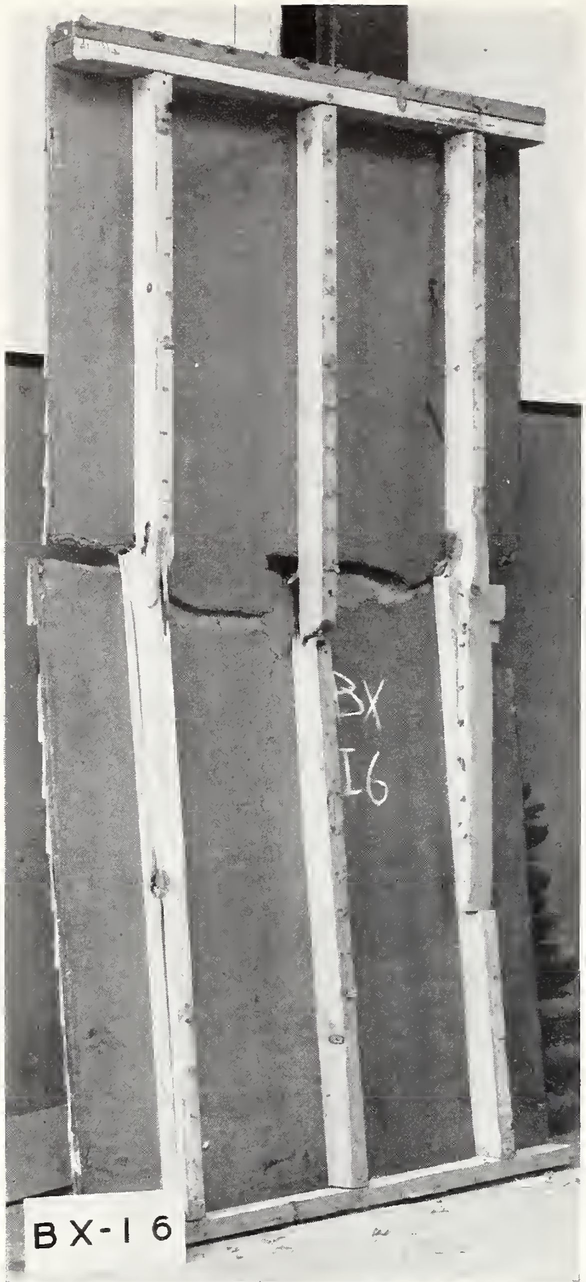

FIGURE 1.—*Typical wall specimen BX.*
Inside (plastered) face removed.

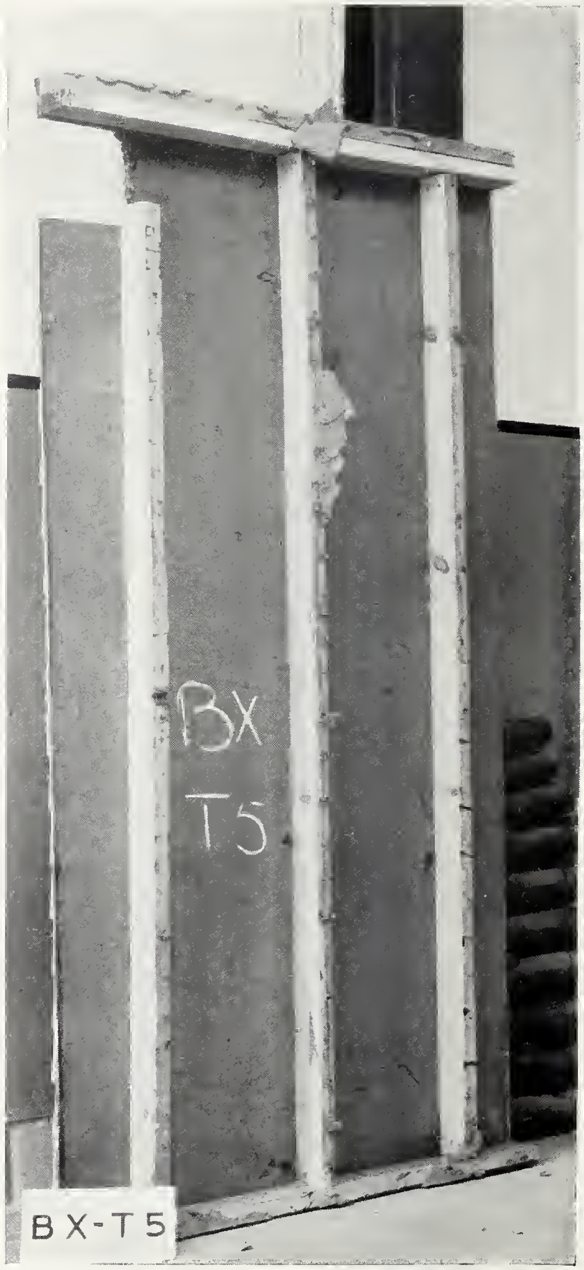

FIGURE 2.—*Typical wall specimen BX.*
Inside (plastered) face removed.

The moisture content of the wood is given in table 3.

An electrical moisture meter was used when determining the moisture content. The meter was graduated for Douglas fir and red cypress. The correction term of the meter for Douglas fir was determined by taking one sample of the wood from the framing of each specimen. Each sample was dried in an oven at 212° F until the weight was constant. The moisture content was the difference between the initial weight and the weight when dry, divided by the weight when dry. The average reading for these samples was 0.4 less than the average of the meter readings, and therefore the moisture content of the Douglas fir was obtained by subtracting 0.4 from the meter readings and rounding the result to the nearest whole number.

For the bevel siding (red cypress) the correction term was not ascertained.

The moisture content of the wood in each specimen was determined on each stud and on the top and floor plates. Measurements were made on about half the pieces of bevel siding.

2. Insulating Board

All the insulating boards were made from bagasse, the fibers of sugarcane after the sugar has been extracted. In the process of manufacture the fibers are cooked and washed repeatedly to remove the soluble matter, then chemically treated to increase water resistance and resistance to rot and termites. The fibers, without the addition of adhesives, are then fabricated into continuous boards. The sponsor's published value for the thermal conductivity of these boards is 0.33 (Btu/hr ft^2)/(°F/in. thickness).

"Celotex" building board.—Rigid building board, ½ in. thick. One surface was smooth and covered with one coat of lithopone casein paint, applied by rollers before the sheets were dry; the other face had a "sanded" finish. The color of the smooth face was deep ivory and that of the "sanded" face neutral tan.

"Celotex Vapor-seal Insulating" sheathing.—Rigid insulating board, $^{25}/_{32}$ in. thick. The entire surface, including the edges, was coated with hot asphalt by dipping. The interior face was covered also with one coat of aluminum paint applied by spraying.

"Celotex Vapor-seal Insulating" lath.—Rigid insulating board, shown in figure 3, ½ in. thick, 1 ft 6 in. by 4 ft 0 in. One surface was coated with asphalt and then with one coat of aluminum paint. The opposite face is intended for the application of plaster. The long edges were shiplapped, and all edges of the face to which the plaster was applied were beveled.

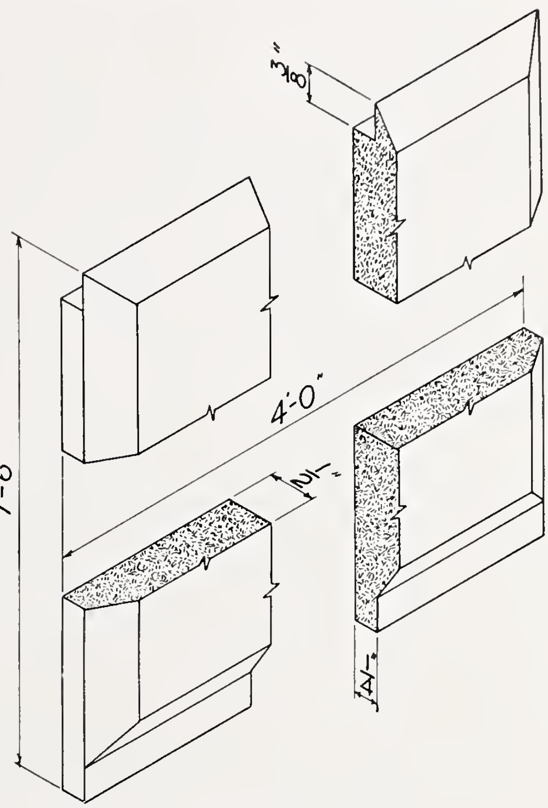

Figure 3.—*"Celotex Vapor-seal Insulating" lath.*

Physical properties.—The physical properties of the insulating boards are given in table 4.

The samples of the boards were taken from the specimens after they had been tested. Probably the properties of the lath were affected by the removal of the plaster.

The transverse strength and deflection at ultimate load, tensile strength, and linear expansion were determined by the Paper Section of this Bureau by the methods described in Federal Specification LLL–F–321a, Fiber

Table 4.—*Physical properties of the building board, sheathing, and lath*

[The samples of insulating board were taken from the wall and partition specimens after the structural properties had been determined. The values may not be representative of current production]

Insulating board	Thickness	Specimen	Transverse test: Strength, Across long direction [a]	Transverse test: Strength, Across short direction [b]	Transverse test: Deflection at ultimate load, Across long direction [a]	Transverse test: Deflection at ultimate load, Across short direction [b]	Tensile strength: Lengthwise of board	Tensile strength: Crosswise of board	Linear expansion for 47-percent relative-humidity change	Density, dry	Nail-holding strength (lateral): Lengthwise of board	Nail-holding strength (lateral): Crosswise of board
	in.		*lb*	*lb*	*in.*	*in.*	*lb/in.*^{2}	*lb/in.*^{2}	*Percent*	*lb/ft*^{3}	*lb*	*lb*
"Celotex" building board	½	*BY-T1*	13.3	11.6	0.82	0.85	270	206	0.2	17.1	55	58
		CA-I3	12.8	10.4	.89	1.01	268	168	.2	17.3	68	54
"Celotex Vapor-seal Insulating" sheathing.	25/32	*BY-T1*	42.5	34.0	.51	0.41	235	144	.3	19.5	122	121
		BX-T1	37.0	28.6	.49	.43	234	162	.1	19.0	117	105
"Celotex Vapor-seal Insulating" lath.	½	*BX-T1*	18.5	14.2	.85	.76	320	225	.2	18.0	71	73
		BZ-I1	18.0	14.5	.78	.81	232	228	.2	18.0	71	73

[a] The samples were cut lengthwise of the board.

[b] The samples were cut crosswise of the board.

Board; Insulating. Because the samples were taken from wall and partition specimens which had been tested, the values may not be representative of current production. The thermal conductivity and water absorption were not measured.

The nail-holding strength was measured by the method described in BMS4, Accelerated Aging of Fiber Building Boards, except that the nails (common, 6d, 2 in. long, No. 11½ steel wire, 0.113-in. diam) were ½ in., not ¾ in., from the edge of the board. The distance was ½ in. because this was approximately the distance from the nails to the edge of the board in the wall and partition specimens.

The moisture content of the building board, sheathing, and lath, determined on one sample from each specimen by oven-drying at 212° F to a constant weight, is given in table 5.

Table 5.—*Moisture content of building board, sheathing, and lath*

[Determined on the day the wall or partition specimen was tested]

Board	Thickness	Construction symbol	Moisture content [a]: Minimum	Moisture content [a]: Maximum	Moisture content [a]: Average
	in.		*Percent*	*Percent*	*Percent*
"Celotex" building board	½	*BY*	6	8	7
		CA	6	6	6
"Celotex Vapor-seal Insulating" sheathing.	25/32	*BY*	4	7	6
		BX	4	6	5
"Celotex Vapor-seal Insulating" lath.	½	*BX*	5	8	6
		BZ	6	7	6

[a] Based on the weight when oven-dry.

3. Nails

The nails were made from steel wire, and the description is given in table 6.

Table 6.—*Description of nails*

Type	Size	Length	Steel wire gage	Diameter	Head	Finish
	Penny	*in.*	*No.*	*in.*	*in.*	
Common brad		1¼	16	0.0625		Bright.
Common	8	2½	10¼	.131		Do.
Do	16	3½	8	.162		Do.
Plasterboard		1¼	13	.0915	5/16	Blued.
Roofing		2	11	.1205	7/16	Zinc-coated.

4. Plaster

Three coats of plaster were applied—a scratch coat 5/16 in. thick, composed of about 1 part of neat gypsum plaster and 2 parts of sand, by weight; a brown coat, ⅛ in. thick, composed of about 1 part of neat gypsum plaster and 3 parts of sand, by weight; and a finish coat, 1/16 in. thick, composed of 1 part of gaging plaster and 3 parts of finishing lime putty, by volume; total thickness, ½ in. The contractor was instructed to apply the plaster to the specimens as he would to the walls of a house.

The neat gypsum plaster was United States Gypsum Co.'s "Red Top"; gaging plaster, Certain-Teed Products Corporation's "Blue Rapids"; and finishing lime, Standard Lime & Stone Co.'s "Washington." The sand was Potomac River building sand, passing a No. 8 mesh sieve.

Unless otherwise stated, the properties of the plaster were determined according to Federal Specification SS–P–401, Plaster; Gypsum. Time of set of the neat gypsum plaster was 12 hr, and the average tensile strength of six samples was 270 lb/in.^{2}—which complied with the requirements in the specification.

A laboratory sample consisting of 1 part of neat gypsum plaster and 2 parts of sand, by weight, had a time of set of 11½ hr and a tensile strength of 150 lb/in.^{2}, when prepared so as to have a slump of ½ in. A laboratory sample consisting of 1 part of neat gypsum plaster and 3 parts of sand, by weight, had a time of set of 9 hr and a tensile strength of 95 lb/in.^{2}, when similarly prepared and tested.

Accelerator was added to the plaster on the job to decrease the time of set. Samples were taken of the plaster for the scratch and brown coats on the plastered specimens *BX* and *BZ*. The physical properties are given in table 7.

Table 7.—*Physical properties of the sanded plaster, wall BX and partition BZ*

Specimens	Slump	Time of set	Tensile strength [a]	Plaster-sand ratio, by weight [b]
BX–C1, C2, T1, P4, P5, I4, I5, R1:	*in.*	*hr*	*lb/in.*^{2}	
Scratch coat	5/16	4	140	1 : 2.19
Brown coat	½	2½	60	1 : 3.37
BX–C3, T2, T3, R2:				
Scratch coat	7/16	4½	120	1 : 2.16
Brown coat	⅜	2½	50	----------
BX–T4, T5, P1, P6, I1, I6:				
Scratch coat	7/16	4½	120	1 : 2.16
Brown coat	1 5/16	3	40	1 : 3.39
BX–T6, P2, P3, I2, I3, R3, BZ–I1, I2, I3:				
Scratch coat	½	5½	130	----------
Brown coat	⅝	3¼	60	----------

[a] Average for 6 hriquets. Determined when the weight was constant within 0.1 percent.

[b] Determination of sand in set plaster: Ammonium acetate method, Report of Committee C–11, Proc. Am. Soc. for Testing Materials, 38, pt. 1, 1323 (1938).

The tensile strength of the sanded plaster varied with the plaster-sand ratio and with the quantity of water in the plaster mix. There are no requirements in Federal Specification SS–P–401 for the tensile strength of plaster which has been sanded on the job.

V. WALL *BX*

1. Sponsor's Statement

Wall *BX* was a wood-frame construction with "Celotex Vapor-seal Insulating" sheathing and wood bevel siding on the outside face, and "Celotex Vapor-seal Insulating" lath and plaster on the inside face.

The price of this construction in Washington, D. C., as of July 1937, was \$0.51/ft^2.

(a) *Four-Foot Wall Specimens*

The 4-ft. wall specimens, shown in figure 4, were 8 ft. 0 in. high, 4 ft. 0 in. wide, and 6 in. thick. Each specimen consisted of a wood frame to which the faces were fastened. The frame consisted of three studs, *A*, fastened to a floor plate, *B*, and to a top plate, *C*, by nails; the outside face, of insulating-board sheathing, *D*, and wood bevel siding, *E*; and the inside face, of insulating-board lath, *F*, and plaster, *G*. The specimens were not painted.

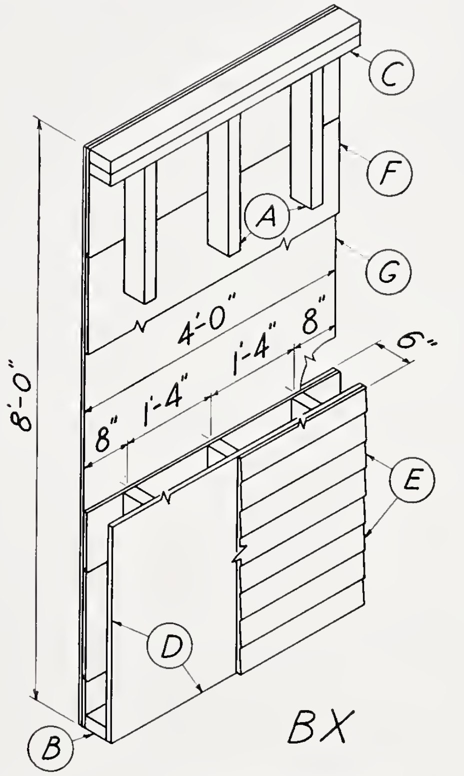

Figure 4.—*Four-foot wall specimen BX.*

A, stud; *B*, floor plate; *C*, top plate; *D*, insulating-board sheathing; *E* bevel siding; *F*, insulating-board lath; and *G*, plaster.

Studs.—The studs, *A*, were Douglas fir, 1⅝ by 3⅝ in. (nominal 2 by 4 in.) by 7 ft. 7⅛ in., S4S (surfaced four sides), spaced 1 ft. 4 in. on centers, and toenailed to the floor plate and top plate with 8d common wire nails, five nails to

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each end, two through each side, and one through one edge of the stud.

Floor plate.—The floor plate, *B*, was Douglas fir, 1⅝ by 3⅝ in. (nominal 2 by 4 in.) by 4 ft. 0 in., S4S.

FIGURE 5.—*Typical wall specimen, BX and BY.*
The splits in the siding are indicated by the arrowheads.

Top plate.—The top plate, *C*, consisted of two pieces of Douglas fir, 1⅝ by 3⅝ in. (nominal 2 by 4 in.) by 4 ft. 0 in., S4S, fastened together by six 16d common wire nails driven from the top of the upper member of the plate, two at each stud.

Sheathing.—The sheathing, *D*, was insulating-board sheathing, 8 ft 0 in. long, 4 ft. 0 in. wide, and 25/32 in. thick, with the aluminum-painted surface against the studs. It was fastened to the wood frame by 2-in. zinc-coated roofing nails spaced 6 in. along studs and 3 in. along both plates.

Bevel siding.—The bevel siding, *E*, was red cypress, 21 pieces, 7/16 by 3/16 by 5½ in., 4 ft. 0 in. long, 4½ in. exposed to the weather. Each strip was fastened along the upper edge by 2-in. zinc-coated roofing nails, one at each stud, and 1¼ in. from the lower edge by 8d common

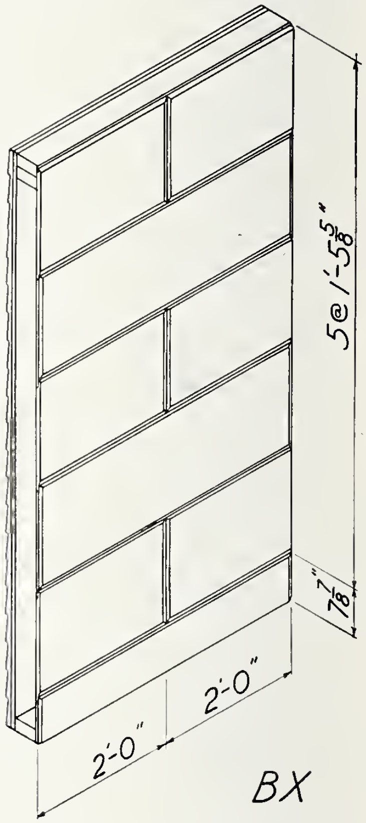

FIGURE 6.—*Wall specimen BX.*
Arrangement of the lath.

wire nails, one at each stud. The 8d nails caused numerous splits in the siding, as shown in figure 5.

Lath.—The lath, *F*, was insulating boards, five full courses and one course cut to a height of 7⅞ in., as shown in figure 6. There was a vertical joint over the center stud in alternate courses of lath. The lath was fastened with the beveled edges away from the studs. The grooves formed by the beveled edges were

designed to give additional bond to the plaster. The edges were in contact, and the lath was fastened to the studs and plates by 1¼-in. plasterboard nails spaced about 3 in.

Plaster.—The plaster, *G*, was ½ in. thick and consisted of a scratch coat, a brown coat, and a finish coat. The lath was dry when the plaster was applied. The overhanging edges were supported by temporary spacers, which were removed immediately before the specimen was tested.

(*b*) *Eight-Foot Wall Specimens*

The 8-ft. wall specimens, shown in figure 7, were 8 ft. 0 in. high, 8 ft. 0 in. face width, and 6 in. thick. The specimens were similar to the 4-ft. specimens, except that there were seven studs, spaced 1 ft. 4 in. on centers. A stud at each edge extended one-half its thickness beyond the faces. The over-all width was 8 ft. 1⅝ in.

Sheathing.—The sheathing consisted of two insulating boards 8 ft 0 in. long and 4 ft 0 in. wide, having a vertical joint on the center stud. The boards were fastened to the edge studs, center stud, floor plate, and top plate by 2-in. zinc-coated roofing nails spaced 3 in., about ½ in. from the edges of the boards; and to the other four studs by 2-in. zinc-coated roofing nails spaced 6 in.

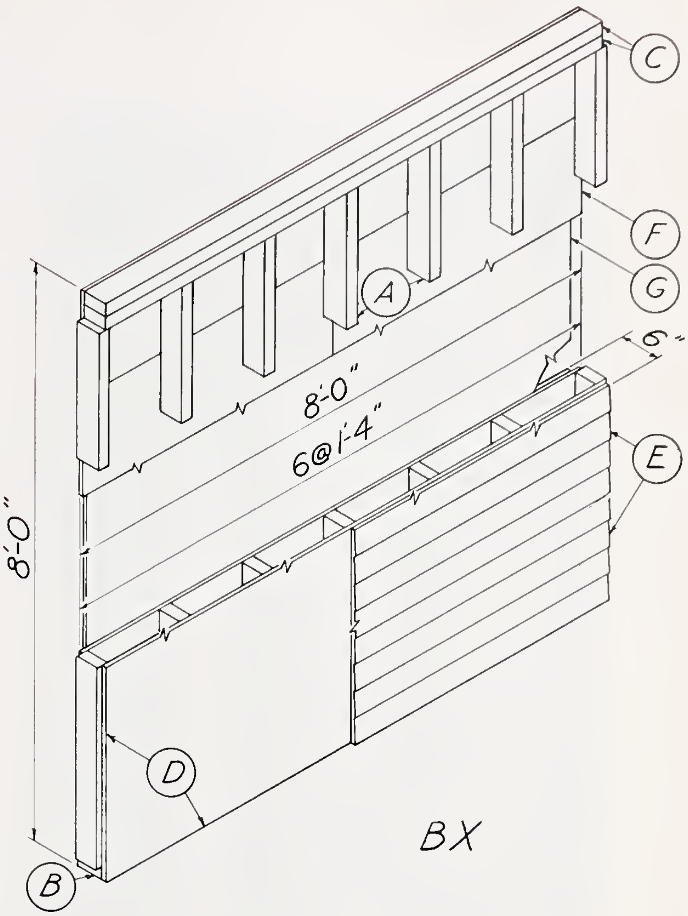

FIGURE 7.—*Eight-foot wall specimen BX.*

A, stud; *B*, floor plate; *C*, top plate; *D*, insulating-board sheathing; *E*, bevel siding; *F*, insulating board lath; and *G*, plaster.

TABLE 8.—*Structural properties, walls BX and BY*

[Weight: Wall *BX*, 9.10 lb/ft²; wall *BY*, 4.70 lb/ft²]

Construction symbol	Load									
	Compressive [a]		Transverse [b]		Concentrated		Impact [b]		Racking	
	Specimen	Maximum load	Specimen	Maximum load	Specimen	Maximum load	Specimen	Maximum height of drop	Specimen	Maximum load
		[c] *Kips/ft*		*lb/ft²*		*lb*		*ft*		[c] *Kips/ft*
BX	*C1*	8.45	*T1*	258	*P1*	308	*I1*	[d] 10.0	*R1*	1.82
	C2	9.75	*T2*	350	*P2*	325	*I2*	[d] 10.0	*R2*	1.62
	C3	7.95	*T3*	345	*P3*	500	*I3*	[d] 10.0	*R3*	1.72
Average		8.72		318		378		[d] 10.0		1.72
BX			*T4*	350	*P4*	950	*I4*	[e] 10.0		
			T5	263	*P5*	774	*I5*	[d] 10.0		
			T6	315	*P6*	600	*I6*	9.0		
Average				309		775				
BY	*C1*	4.45	*T1*	259	*P1*	115	*I1*	[d] 10.0	*R1*	1.48
	C2	4.92	*T2*	255	*P2*	103	*I2*	[d] 10.0	*R2*	1.30
	C3	4.25	*T3*	350	*P3*	101	*I3*	[d] 10.0	*R3*	1.40
Average		4.54		288		106		[d] 10.0		1.39
BY			*T4*	177	*P4*	500	*I4*	[d] 10.0		
			T5	305	*P5*	900	*I5*	[e] 10.0		
			T6	260	*P6*	600	*I6*	[e] 10.0		
Average				247		666				

[a] The compressive loads were applied 1.21 in. (one-third the thickness of the frame) from the inside surface of the studs.
[b] Span 7 ft 6 in.
[c] A kip is 1,000 lb.
[d] Specimen did not fail. No studs broken. Test discontinued.
[e] One or more studs broken. Test discontinued.

Figure 8.—*Wall specimen BX-C1 under compressive load.*

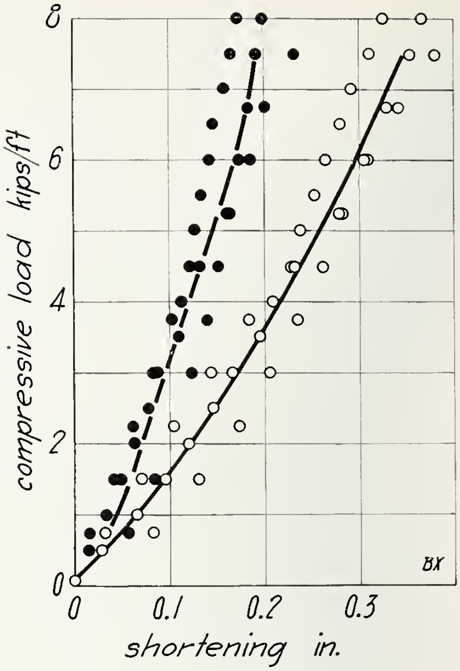

Figure 9.—*Compressive load on wall BX.*

Load-shortening (open circles) and load-set (solid circles) results for specimens *BX-C1*, *C2*, and *C3*. Load was applied 1.21 in. (one-third the thickness of the frame) from the inside surface of the studs. The loads are in kips per foot of actual width of specimen.

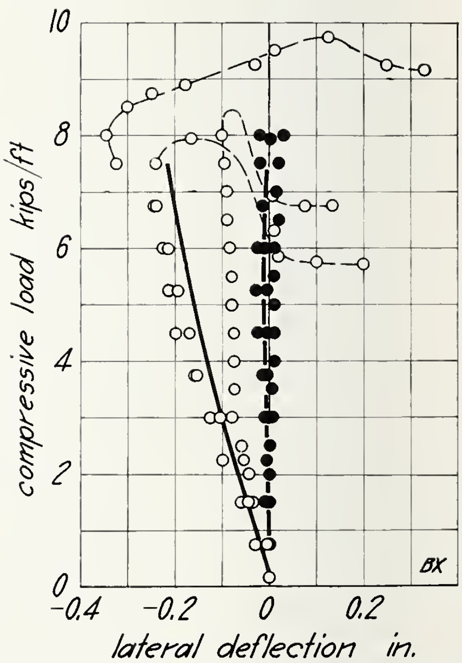

Figure 10.—*Compressive load on wall BX.*

Load-lateral deflection (open circles) and load-lateral set (solid circles) results for specimens *BX-C1*, *C2*, and *C3*. Load applied 1.21 in. (one-third the thickness of the frame) from the inside surface of the studs. The loads are in kips per foot of actual width of specimen. The deflections are for a gage length of 7 ft 10 in., the gage length of the deflectometers.

2. Compressive Load

Wall specimen *BX–C1* under compressive load is shown in figure 8. The results for wall specimens *BX–C1*, *C2*, and *C3* are shown in table 8 and in figures 9 and 10.

The lateral deflections shown in figure 10 were plotted to the right of the vertical axis for deflections of the specimen at midheight toward the outside face (positive deflection) and to the left for deflections toward the inside (plastered) face (negative deflection).

Although the load was eccentric toward the inside face, each of the specimens deflected initially toward the inside face, probably because the stiffness of the plaster counteracted the effect of the eccentric load. The deflections of the specimens were similar to the deflections under similar eccentric loads of other wood-frame constructions, as described in report BMS25, Structural Properties of Conventional Wood-Frame Constructions for Walls, Partitions, Floors, and Roofs, and report BMS31, Structural Properties of "Insulite" Wall and "Insulite" Partition Constructions Sponsored by The Insulite Co. As the maximum load was approached, the deflections toward the inside face decreased. At the maximum loads the deflection of specimens *C1* and *C3* was toward the inside face and that of *C2* was toward the outside face. The dotted lines in figure 10 show the relation between lateral deflection and load for each of the specimens after the maximum load. The change in the direction of the deflection curve probably indicates progressive local failure of the plaster.

Each of the specimens failed by crushing of the edges of the plaster at the top and bottom of the specimen and by crushing of the studs into the lower member of the top plate adjacent to the inside (plastered) face. The lath separated from the studs at the top plate, and in specimen *C3* also at the floor plate. No studs were ruptured except one stud of specimen *C1*, which was split along the grain for 6 in. at the top.

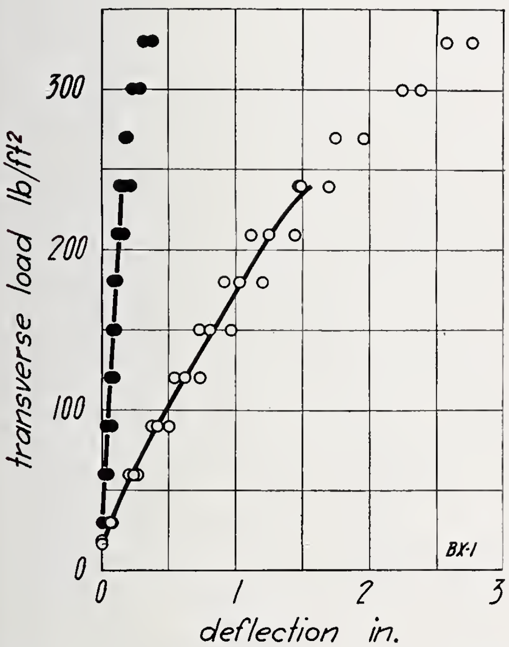

Figure 11.—*Transverse load on wall BX, load applied to inside face.*

Load-deflection (open circles) and load-set (solid circles) results for specimens *BX–T1*, *T2*, and *T3* on the span 7 ft 6 in.

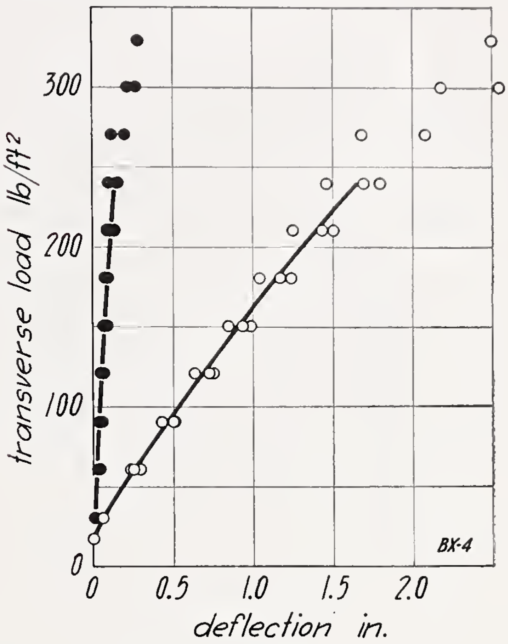

Figure 12.—*Transverse load on wall BX, load applied to outside face.*

Load-deflection (open circles) and load-set (solid circles) results for specimens *BX–T4*, *T5*, and *T6* on the span 7 ft 6 in.

3. Transverse Load

The results of the transverse-load test are shown in table 8 and in figure 11 for wall specimens *BX–T1*, *T2*, and *T3*, loaded on the inside (plastered) face, and in figure 12 for wall specimens *BX–T4*, *T5*, and *T6*, loaded on the outside face.

The loaded (plastered) face of specimens *T1*, *T2*, and *T3* cracked longitudinally along both outer studs and transversely (across the specimen) in several places. The first longitudinal cracks in specimen *T1* occurred at a load of 90 lb/ft^2 and a deflection of 0.36 in. There were longitudinal cracks in specimens *T2* and *T3* before they were tested. The first transverse cracks occurred at lath joints at or between the loading rollers and were observed in specimens *T1*, *T2*, and *T3* after loads of 240, 180, and 150 lb/ft^2 and deflections of 1.49, 1.20, and 0.81 in., respectively. At the maximum load specimen *T1* failed by rupture of one outer stud across the grain at a loading roller, accompanied by rupture of the sheathing and lath at the same place. Specimen *T2* failed by rupture of one outer stud at a knot near midspan, the sheathing rupturing at the same place. An outer stud in specimen *T3* cracked in compression at a knot near midspan at a load of 272 lb/ft^2. Specimen *T3* failed by rupture of this stud at the knot and by splitting of the center stud along the grain, starting at a knot near midspan. The siding on all the specimens was undamaged.

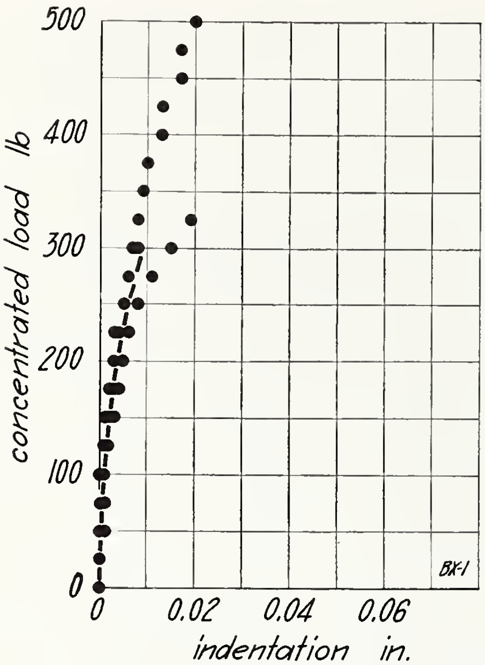

Figure 13.—*Concentrated load on wall BX, load applied to inside face.*

Load-indentation results for specimens *BX–P1*, *P2*, and *P3*.

The plaster on specimens *T4*, *T5*, and *T6*, loaded on the outside (bevel siding) face, cracked transversely (across the specimen) in several places, the largest cracks being at lath joints. The first transverse cracks occurred at loads of 50, 60, and 77 lb/ft^2 and deflections of 0.18, 0.29, and 0.39 in. in specimens *T4*, *T5*, and *T6*, respectively. One outer stud of specimen *T4* partially ruptured at a knot near midspan at a load of 300 lb/ft^2. At the maximum load specimen *T4* failed by further rupture of the same outer stud and by splitting of the center stud along the grain near midspan. Specimen *T5* failed by splitting of one outer stud along the grain at a knot near midspan. One outer stud of specimen *T6* partially ruptured at a knot under a loading roller at a load of 283 lb/ft^2. At the maximum load specimen *T6* failed by splitting along the grain of the other outer stud at a loading roller. The sheathing and siding of specimens *T4*, *T5*, and *T6* were undamaged.

4. Concentrated Load

The results of the concentrated-load test are shown in table 8 and in figure 13 for wall specimens *BX–P1*, *P2*, and *P3*, loaded on the inside (plastered) face, and in figure 14 for wall specimens *BX–P4*, *P5*, and *P6*, loaded on the outside face.

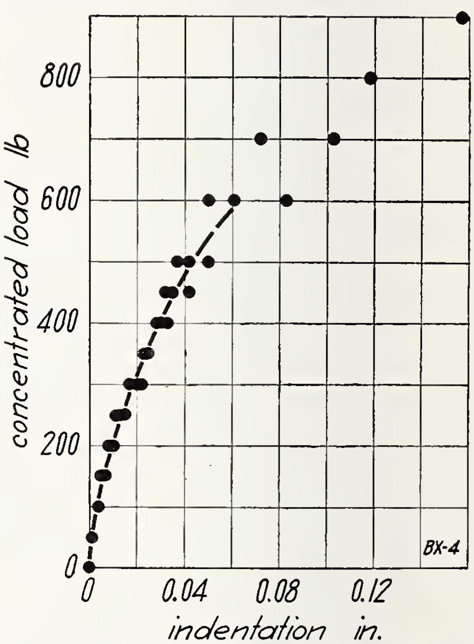

Figure 14.—*Concentrated load on wall BX, load applied to outside face.*

Load-indentation results for specimens *BX–P4*, *P5*, and *P6*.

The concentrated loads were applied to the inside face of specimens *P1*, *P2*, and *P3* on the plaster midway between two studs and about 2 ft 6 in. from one end of the specimen. Each of the specimens failed by punching of the disk through the plaster and into the lath.

The concentrated loads were applied to the outside face of specimens *P4*, *P5*, and *P6* on a strip of siding midway between two studs and about 1½ in. from the lower edge of the strip. Under a load of 300 lb on specimen *P5* the siding split along the grain tangent to one edge of the disk. Under the maximum load on specimen *P5* the siding split along the grain on opposite edges of the disk and crushed under the disk. Specimens *P4* and *P6* failed by splitting of the siding along the grain tangent to one edge of the disk.

5. Impact Load

The results of the impact test are shown in tables 8, 9, and 10 and in figure 15 for wall specimens *BX–I1*, *I2*, and *I3*, loaded on the

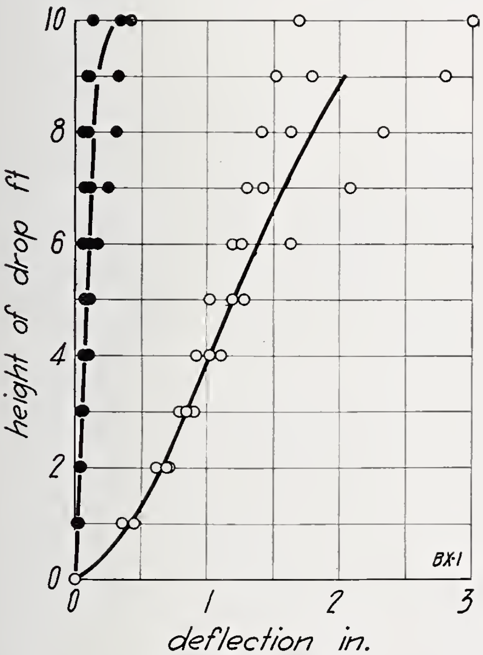

Figure 15.—*Impact load on wall BX, load applied to inside face.*

Height of drop-deflection (open circles) and height of drop-set (solid circles) results for specimens *BX–I1*, *I2*, and *I3* on the span 7 ft 6 in.

inside (plastered) face, and in figure 16 for wall specimens *BX–I4*, *I5*, and *I6*, loaded on the outside face.

The impact loads were applied to the center of the inside face of specimens *I1*, *I2*, and *I3*, the sandbag striking the plaster directly over

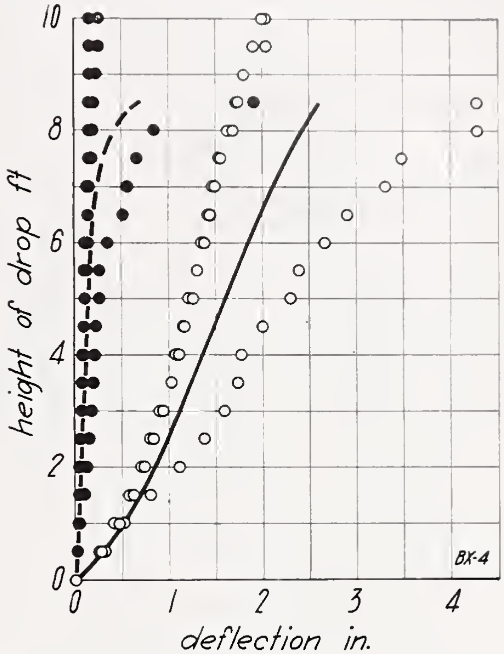

Figure 16.—*Impact load on wall BX, load applied to outside face.*

Height of drop-deflection (open circles) and height of drop-set (solid circles) results for specimens *BX–I4*, *I5*, and *I6* on the span 7 ft 6 in.

the center stud. The effects of the impact loads are given in table 9.

Table 9.—*Effects of impact load on wall BX, loaded on the inside (plastered) face*

Description of effects	Specimen *I1*		Specimen *I2*		Specimen *I3*	
	Height of drop	Deflection	Height of drop	Deflection	Height of drop	Deflection
Plaster:	*ft*	*in.*	*ft*	*in.*	*ft*	*in.*
Cracked along outer studs	0.0	0.00	1.0	0.36	1.0	0.45
Cracked transversely along a lath joint	3.0	.84	4.0	.91	4.0	1.10
Failure by spalling along previous cracks	4.0	1.01			4.5	1.20
Failure by rupture of lath and plaster along outer studs			5.0	1.02		
Lath ruptured under the sandbag	5.0	1.19	7.5	1.35	5.0	1.28
Face not loaded, failure by separation of siding from sheathing					9.5	2.90

After the 10-ft drop the set of specimen *I1* was 0.42 in.; of specimen *I2*, 0.13 in.; and of specimen *I3*, 0.34 in. No studs were broken, and the sheathing was not separated from the studs.

The impact loads were applied to the center of the outside face of specimens *I4*, *I5*, and *I6*, the sandbag striking the bevel siding directly over the center stud. The effects of the impact loads are given in table 10.

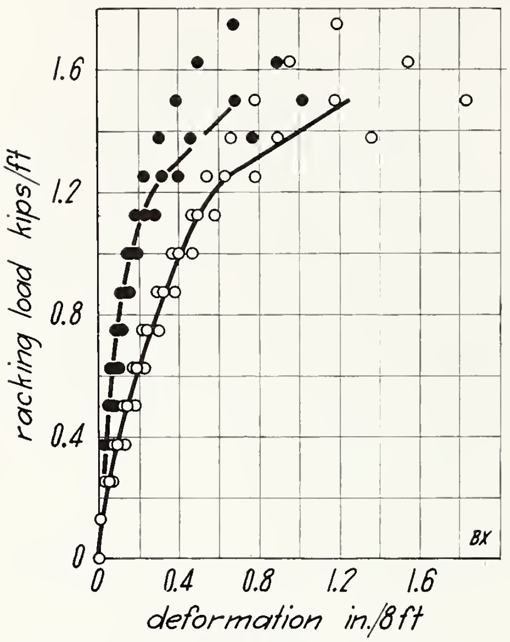

FIGURE 17.—*Racking load on wall BX.*

Load-deformation (open circles) and load-set (solid circles) results for specimens *BX-R1, R2, and R3*. The loads are in kips per foot of the face width of specimen.

TABLE 10.—*Effects of impact load on wall BX, loaded on the outside (bevel siding) face*

Description of effects	Specimen *I4*		Specimen *I5*		Specimen *I6*	
	Height of drop	Deflection	Height of drop	Deflection	Height of drop	Deflection
Plaster:						
Cracked along one or more studs	*ft* 2.5	*in.* 0.83	*ft* 1.5	*in.* 0.58	*ft* 1.0	*in.* 0.52
Cracked transversely	2.5	.83	2.5	.80	1.0	.52
Failure by spalling at previous cracks	4.0	1.10	4.0	1.07	4.0	1.78
Center stud ruptured	------	------	------	------	5.5	2.38
Pieces of plaster fell off the specimen	8.0	1.68	8.0	1.62	7.0	3.31
Outer stud cracked	9.0	1.80	------	------	6.0	2.67
	------	------	------	------	8.5	4.29
Failure of loaded face, specimen broke in two	------	------	------	------	9.0	------

The sets after the 10-ft drop on specimens *I4* and *I5* were 0.26 and 0.16 in., respectively. One outer stud and one siding strip of specimen *I4* were split, but the outside face and sheathing did not separate from the studs. The studs and siding of specimen *I5* were not cracked, but the sheathing ruptured partially at midspan.

6. RACKING LOAD

The racking-load test results for wall specimens *BX-R1*, *R2*, and *R3* are shown in table 8 and in figure 17.

The racking loads were applied only to the top plate, and the stop was in contact only with the floor plate at the diagonally opposite corner of the specimen.

The inside (plastered) faces of the specimens cracked in several places. In specimens *R1*, *R2*, and *R3* the first cracks occurred at loads of 1.625, 1.125, and 1.125 kips/ft and deformations of 0.95, 0.59, and 0.49 in./8 ft, respectively. These cracks were parallel to a diagonal from the point of application of the load to the stop. The plaster also cracked along horizontal and vertical lath joints. At the maximum loads each of the specimens failed by pulling of some of the nails through the edges of the sheathing and the lath, by displacement of the sheathing panels along the vertical joint, and by separation of the lath from the studs. In specimen *R3* the top plate separated ¼ in. from the studs.

VI. WALL *BY*

1. SPONSOR'S STATEMENT

Wall *BY* consisted of a wood frame with "Celotex Vapor-seal Insulating" sheathing and wood bevel siding on the outside face, and with "Celotex" building board on the inside face. It was similar to construction *BX*, except that the inside face was building board, not lath and plaster.

The price of this construction in Washington, D. C., as of July 1937, was $0.415/ft^2.

(a) *Four-Foot Wall Specimens*

The 4 ft wall specimens, shown in figure 18, were 8 ft 0 in. high, 4 ft 0 in. wide, and 5½ in. thick, each a wood frame to which the faces were fastened. The frame consisted of three studs, *A*, fastened to a floor plate, *B*, and to a top plate, *C*, by nails. The outside face was insulating-board sheathing, *D*, and wood bevel siding, *E*. The inside face was building board, *F*. The specimens were not painted.

Studs.—The studs, *A*, were Douglas fir, 1⅝ by 3⅝ in. (nominal 2 by 4 in.) by 7 ft 7⅛ in., S4S

(surfaced four sides), spaced 1 ft 4 in. on centers, and toenailed to the plates with 8d common nails, five to each end, two through each side, and one through one edge of the stud.

Floor plate.—The floor plate, *B*, was Douglas fir, 1⅝ by 3⅝ in. (nominal 2 by 4 in.) by 4 ft 0 in., S4S.

Top plate.—The top plate, *C*, consisted of two pieces of Douglas fir, 1⅝ by 3⅝ in. (nominal 2 by 4 in.) by 4 ft 0 in., S4S, fastened together by six 16d common wire nails driven from the top of the upper member of the plate, two at each stud.

Sheathing.—The sheathing, *D*, was insulating-board sheathing, 8 ft 0 in. long, 4 ft 0 in. wide, and 25/32 in. thick, with the aluminum-painted surface against the studs. It was fastened to the frame by 2-in. zinc-coated roofing nails

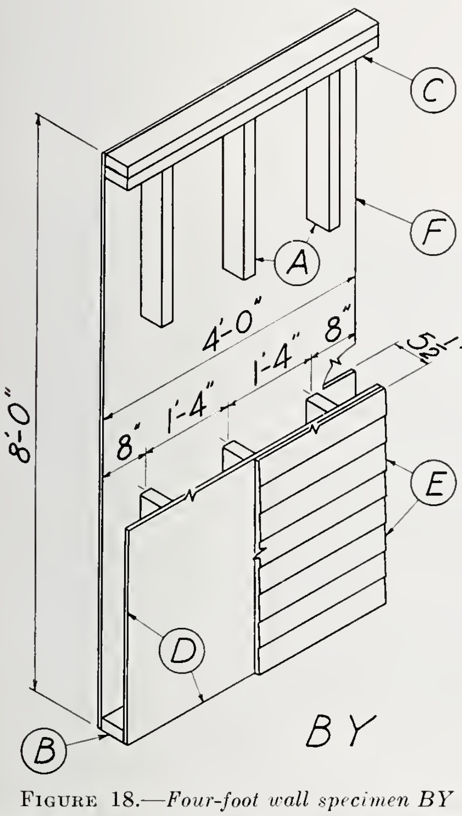

FIGURE 18.—*Four-foot wall specimen BY*

A, stud; *B*, floor plate; *C*, top plate; *D*, insulating-board sheathing; *E*, wood bevel siding; *F*, building board.

spaced 6 in. along studs and 3 in. along both plates.

Bevel siding.—The bevel siding, *E*, was red cypress, 21 pieces, 7/16 by 3/16 by 5½ in., 4 ft 0 in. long, exposed 4½ in. to the weather. Each strip was fastened along the upper edge by 2-in. zinc-coated roofing nails, one at each stud, and 1¼ in. from the lower edge by 8d common

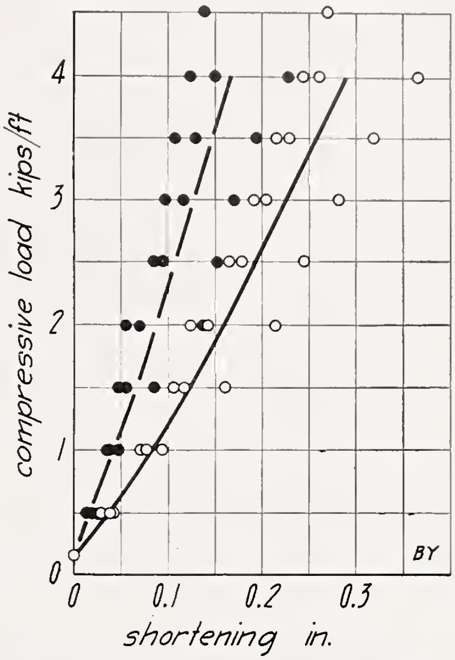

FIGURE 19.—*Compressive load on wall BY.*

Load-shortening (open circles) and load-set (solid circles) results for specimens *BY–C1*, *C2*, and *C3*. Load applied 1.21 in. (one-third the thickness of the frame) from the inside surface of the studs. The loads are in kips per foot of actual width of specimen.

wire nails, one at each stud. The 8d nails caused numerous splits in the siding, as shown in figure 5.

Building board.—The building board, *F*, 8 ft 0 in. long, 4 ft 0 in. wide, and ½ in. thick, fastened to the frame by 1¼-in. brads spaced 6 in. along studs and 3 in. along both plates.

(*b*) *Eight-Foot Wall Specimens*

The 8-ft wall specimens were 8 ft 0 in. high, 8 ft 0 in. face width, and 5½ in. thick, and were similar to the 8-ft specimens of wall *BX*, shown in figure 7, except that the inside face was building board, not lath and plaster.

Building board.—The building board consisted of two boards 8 ft 0 in. long and 4 ft. 0 in. wide, having a vertical joint over the center stud. The boards were fastened to the edge studs, center stud, top plate, and floor plate by 1¼-in. brads spaced 3 in., and to the other four studs by 1¼ in. brads spaced 6 in.

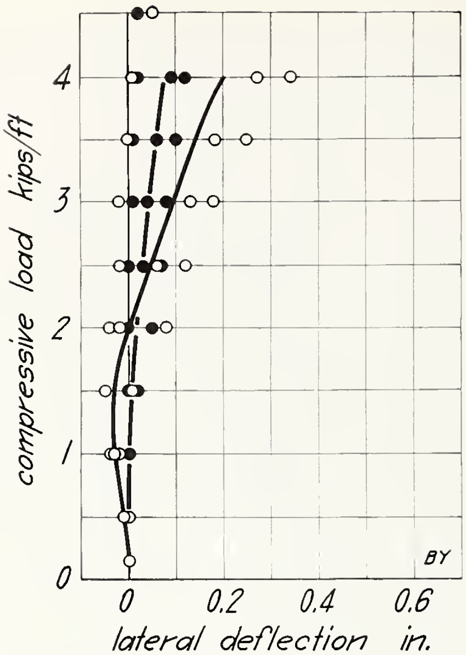

FIGURE 20.—*Compressive load on wall BY.*

Load-lateral deflection (open circles) and load-lateral set (solid circles) results for specimens *BY–C1*, *C2*, and *C3*. Load applied 1.21 in. (one-third the thickness of the frame) from the inside surface of the studs. The loads are in kips per foot of actual width of specimen. The lateral deflections are for a gage length of 7 ft 10 in., the gage length of the deflectometers.

2. Compressive Load

The results for wall specimens *BY–C1*, *C2*, and *C3* under compressive load are shown in table 8 and in figures 19 and 20.

In figure 20 the lateral deflections were plotted to the right of the vertical axis for deflections of the specimens at midheight toward the outside face (positive deflection) and to the left for deflections toward the inside face (negative deflection). The deflection of the specimens toward the inside (building board) face under loads less than 3.5 kips/ft is similar to the deflections under eccentric compressive loads found for other wood-frame constructions, as described in reports BMS25 and BMS31.

The building board separated from all the studs of specimen *C1* under a load of 3.0 kips/ft, of specimen *C2* under a load of 2.2 kips/ft, and of specimen *C3* under a load of 1.9 kips/ft. At the maximum load the top plate of each specimen crushed locally at the inside surface of the studs and separated at the outside surface. The top plate rotated, pulling the nails from

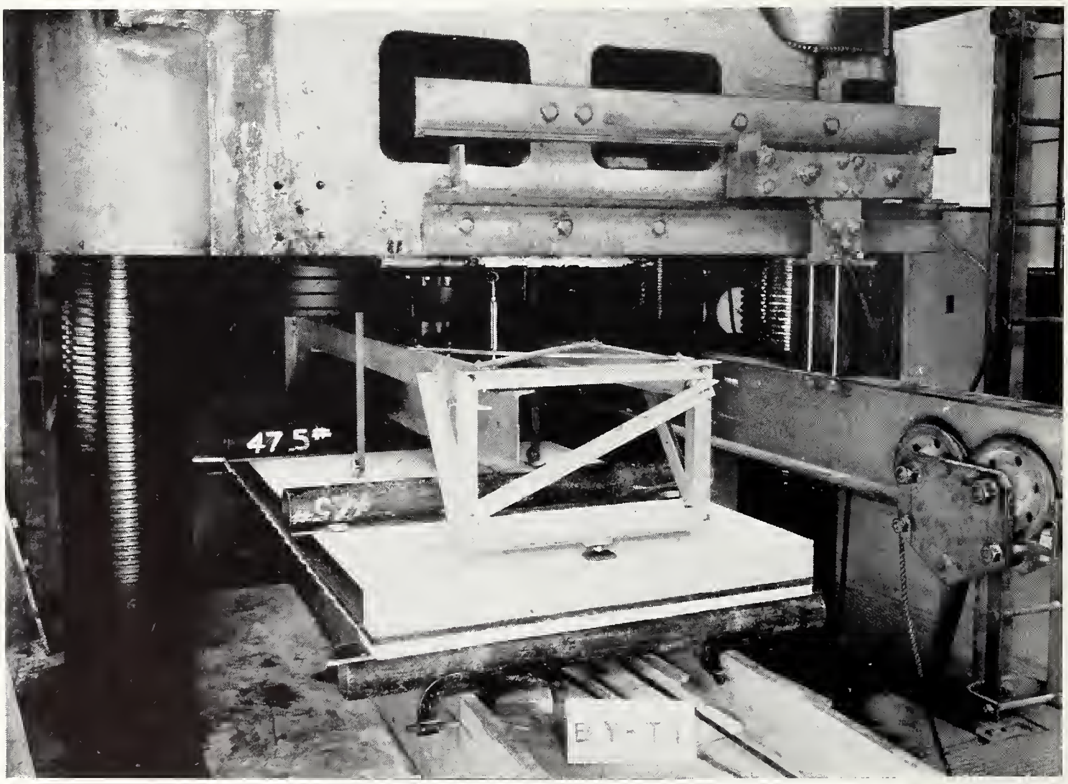

FIGURE 21.—*Wall specimen BY–T1 under transverse load.*

the studs and allowing the specimens to push out under load without breaking the studs.

3. Transverse Load

Wall specimen *BY–T1* under transverse load is shown in figure 21. The results are given in table 8 and in figure 22 for wall specimens *BY–T1*, *T2*, and *T3*, loaded on the inside face, and in figure 23 for wall specimens *BY–T4*, *T5*, and *T6*, loaded on the outside face.

One outer stud of specimen *T1* ruptured at a load of 223 lb/ft^2; and at a load of 285 lb/ft^2 the building board of specimen *T3* buckled between one loading roller and midspan, the heads of the nails pulling through the board. At the maximum loads specimens *T1*, *T2*, and *T3* failed by rupture of the center and one outer stud at or between the loading rollers.

One outer stud of specimen *T4* split at a knot under a load of 118 lb/ft^2, and at the maximum load all the studs broke at one of the loading rollers and the building board ruptured at the same place. Specimen *T5* failed by rupture of one outer stud near midspan, and specimen *T6* failed by rupture of the center stud, also near midspan.

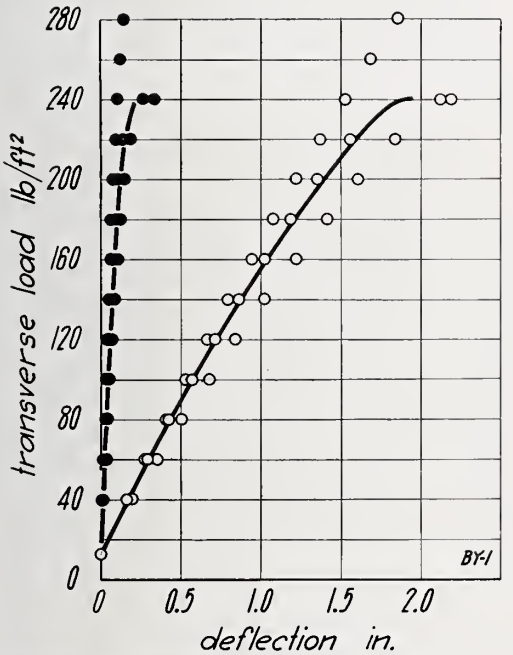

Figure 22.—*Transverse load on wall BY, loaded on the inside face.*

Load-deflection (open circles) and load-set (solid circles) results for specimens *BY–T1*, *T2*, and *T3* on the span 7 ft 6 in.

4. Concentrated Load

Results of the concentrated-load test are shown in table 8 and in figure 24 for wall specimens *BY–P1*, *P2*, and *P3*, loaded on the inside face, and in figure 25 for wall specimens *BY–P4*, *P5*, and *P6*, loaded on the outside face.

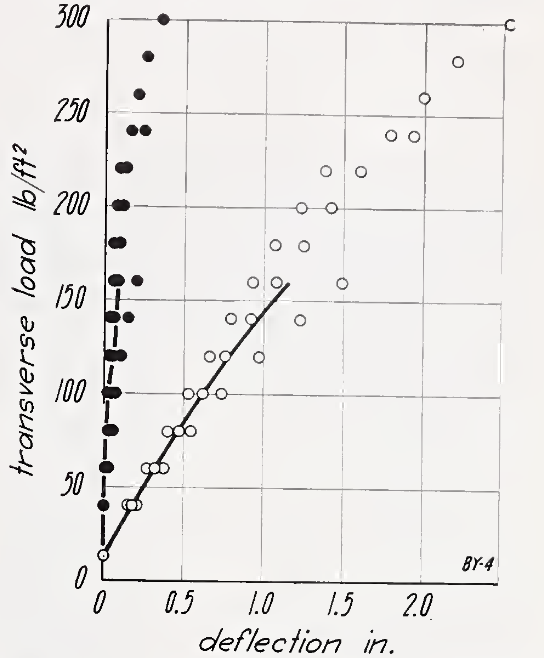

Figure 23.—*Transverse load on wall BY, loaded on the outside face.*

Load-deflection (open circles) and load-set (solid circles) results for specimens *BY–T4*, *T5*, and *T6* on the span 7 ft 6 in.

The concentrated loads were applied to the inside face of specimens *P1*, *P2*, and *P3*, on the building board midway between two studs and about 2 ft from one end. Specimens *P1*, *P2*, and *P3* failed by punching of the disk through the building board.

The concentrated loads were applied to the outside face of specimens *P4*, *P5*, and *P6*, on the bevel siding 1½ in. from the lower edge of a strip of siding midway between two studs and about 4 ft from one end. At the maximum load each of the specimens failed by splitting of the siding along the grain at opposite edges of the disk.

5. Impact Load

Results of the impact test are shown in tables 8 and 11 and in figure 26 for wall specimens *BY–I1*, *I2*, and *I3*, loaded on the inside (building board) face, and in figure 27 for wall speci-

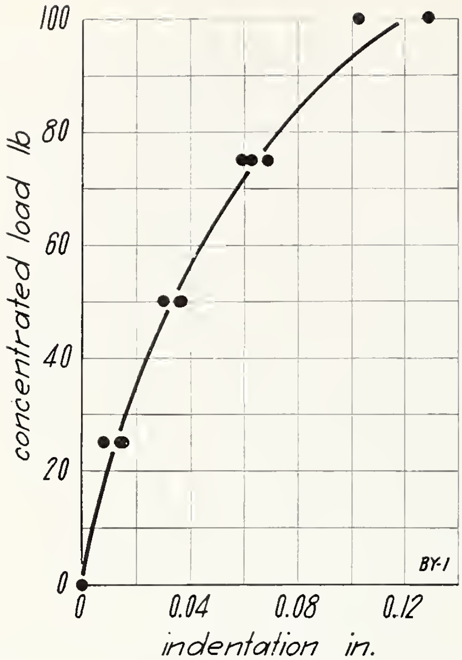

Figure 24.—*Concentrated load on wall BY, load applied to inside face.*

Load-indentation results for specimens *BY-P1, P2,* and *P3.*

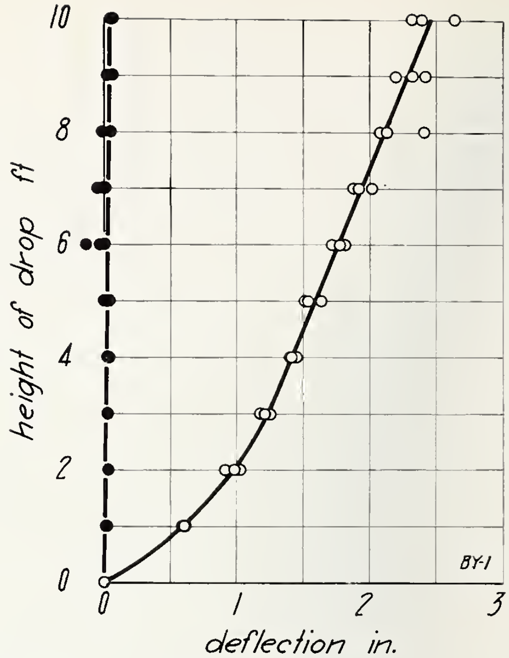

Figure 26.—*Impact load on wall BY, load applied to inside face.*

Height of drop-deflection (open circles) and height of drop-set (solid circles) results for specimens *BY-I1, I2,* and *I3* on the span 7 ft 6 in.

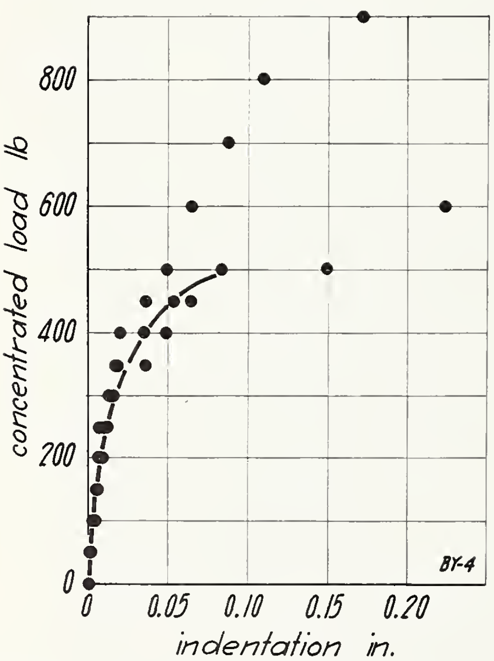

Figure 25.—*Concentrated load on wall BY, load applied to outside face.*

Load-indentation results for specimens *BY-P4, P5,* and *P6.*

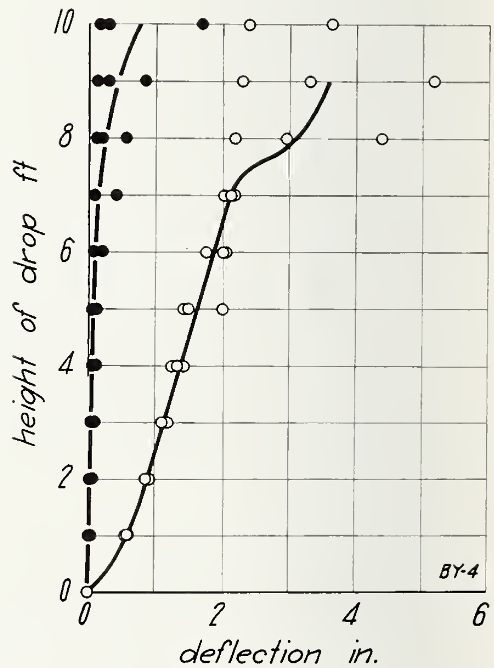

Figure 27.—*Impact load on wall BY, load applied to outside face.*

Height of drop-deflection (open circles) and height of drop-set (solid circles) results for specimens *BY-I4, I5,* and *I6* on the span 7 ft 6 in.

mens *BY–I4*, *I5*, and *I6*, loaded on the outside face.

The impact loads were applied to the center of the inside face of specimens *I1*, *I2*, and *I3*, the sandbag striking the building board directly over the center stud. The effects are given in table 11.

TABLE 11.—*Effects of impact load on wall BY, loaded on the inside face*

Description of effects on the loaded (building board) face	Specimen *I1*		Specimen *I2*		Specimen *I3*	
	Height of drop	Deflection	Height of drop	Deflection	Height of drop	Deflection
	ft	*in.*	*ft*	*in.*	*ft*	*in.*
Separation between studs and building board	3.0	1.21	2.5	1.15	5.0	1.51
Building board cracked under bag	3.5	1.30	2.0	1.02	4.5	1.40
Failure of face by rupture of the building board	5.0	1.54	3.0	1.25	6.5	1.88

The negative values of the set shown in figure 26 were caused by separation of the building board from the studs. The sets after a drop of 10 ft were 0.072, 0.054, and 0.049 in. for specimens *I1*, *I2*, and *I3*, respectively. The studs, sheathing, and siding did not fail, and the sheathing did not separate from the studs.

The impact loads were applied to the outside face of specimens *I4*, *I5*, and *I6*, the sandbag striking the siding directly over the center stud. In these specimens the building board separated from the studs at midspan at drops of 2.0, 2.5, and 1.5 ft, respectively, the heads of the nails pulling through the board. At the maximum loads the building board separated completely from the studs except near the top and bottom of the specimens. In specimen *I4* the studs, sheathing, and siding did not fail. In specimen *I5* the center stud ruptured at a drop of 7.5 ft and the outer studs at a drop of 10 ft. In specimen *I6* the center stud cracked at a drop of 6.0 ft, one outer stud ruptured at a drop of 7.0 ft, and at a drop of 9.0 ft the face not loaded failed by rupture of the building board. The sets after a drop of 10 ft on specimens *I4*, *I5*, and *I6* were 0.159, 0.296, and 1.707 in., respectively.

6. Racking Load

Wall specimen *BY–R1* under racking load is shown in figure 28. The results for wall specimens *BY–R1*, *R2*, and *R3* are given in table 8 and in figure 29.

The racking loads were applied only to the top plate and the stop was in contact only with the floor plate. At loads of 1.125, 1.125, and 0.875 kips/ft on specimens *R1*, *R2*, and *R3*, respectively, there was noticeable vertical displacement of the building board at the joint. At the maximum loads the nails along the top plate and the upper part of the edge studs pulled through the edges of the board. The nails tore through the edge of the sheathing along the edge stud which was against the stop, the vertical displacement increasing both between the two building boards and between the two sheathing boards. Also, the top plate separated from the tops of the studs.

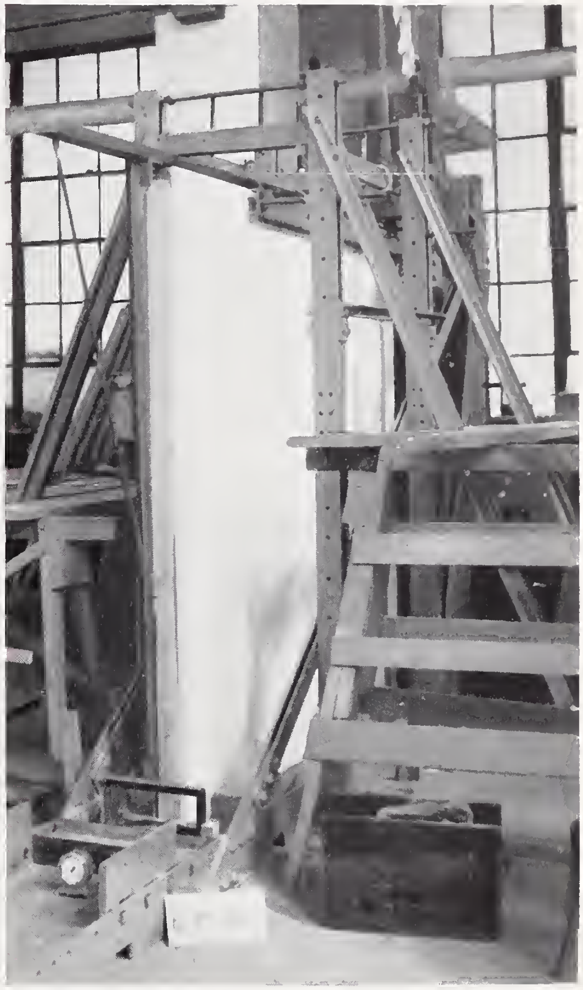

FIGURE 28.—*Wall specimen BY-R1 under racking load.*

VII. PARTITION *BZ*

1. Sponsor's Statement

Partition *BZ* was a wood-frame construction with plaster and "Celotex Vapor-seal Insulating" lath on both faces. The frame was similar to that of walls *BX* and *BY*, and both faces were similar to the inside face of wall *BX*.

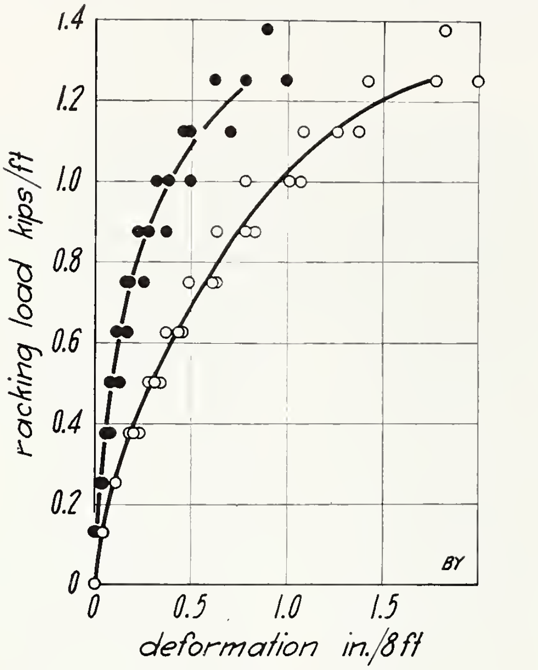

Figure 29.—*Racking load on wall BY.*

Load-deformation (open circles) and load-set (solid circles) results for specimens *BY-R1*, *R2*, and *R3*. The loads are in kips per foot of the face width of specimen.

The price of this construction in Washington, D. C., as of July 1937, was $0.44/ft^2.

The partition specimens, shown in figure 30, were 8 ft 0 in. high, 4 ft 0 in. wide, and 5⅝ in. thick; and they consisted of a frame of three studs, *A*, fastened to a floor plate, *B*, and a top plate, *C*, by nails, with insulating-board lath, *D*, and plaster, *E*, as both faces. The specimens were not painted.

Studs.—The studs, *A*, were Douglas fir, 1⅝ by 3⅝ in. (nominal 2 by 4 in.) by 7 ft 7⅛ in., S4S (surfaced four sides), spaced 1 ft 4 in. on centers, and toenailed to the plates with 8d common wire nails, five nails to each end, two through each side, and one through the edge of the stud.

Floor plate.—The floor plate, *B*, was Douglas fir, 1⅝ by 3⅝ in. (nominal 2 by 4 in.) by 4 ft 0 in., S4S.

Top plate.—The top plate, *C*, was two pieces of Douglas fir, 1⅝ by 3⅝ in. (nominal 2 by 4 in.) by 4 ft 0 in., S4S, fastened together by six 16d common wire nails driven from the top of the upper member of the plate, two at each stud.

Lath.—The lath, *D*, was insulating board, five full courses and one course cut to a height of 7⅞ in., as shown in figure 6. There was a vertical joint over the center stud in alternate courses of lath. The lath was fastened with the beveled edges away from the studs, forming grooves designed to give additional bond to the plaster. The edges were in moderate contact, and the lath was fastened to the framing with 1¼-in. wire plasterboard nails spaced about 3 in.

Plaster.—The plaster, *E*, was ½ in. thick and consisted of a scratch coat, a brown coat, and a finish coat. The lath was dry when the plaster was applied. The overhanging edges were supported by temporary spacers, which were removed immediately before the specimen was tested.

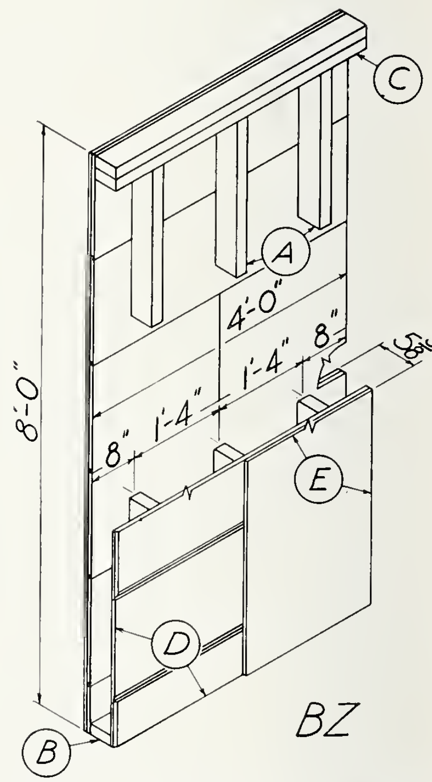

Figure 30.—*Partition specimen BZ.*

A, studs; *B*, floor plate; *C*, top plate; *D*, insulating-board lath; *E*, plaster.

2. Concentrated Load

The results for partition specimens *BZ–P1*, *P2*, and *P3* under concentrated load are shown in table 12 and in figure 31.

Table 12.—*Structural properties, partitions BZ and CA*

[Weight: Partition *BZ*, 11.1 lb/ft.²; partition *CA*, 3.03 lb/ft.²]

Construction symbol	Load			
	Concentrated		Impact [a]	
	Specimen	Maximum load	Specimen	Maximum height of drop
		lb		*ft*
BZ	*P1*	339	*I1*	[b] 10.0
	P2	185	*I2*	7.5
	P3	359	*I3*	[b] 10.0
Average		294		
CA	*P1*	100	*I1*	8.0
	P2	100	*I2*	[b] 10.0
	P3	107	*I3*	8.0
Average		102		

[a] Span 7 ft 6 in.
[b] Test discontinued.

The concentrated loads were applied to the specimens on the plaster midway between two studs and 2 to 3 ft from one end. At the maximum loads the specimens failed by punching of the disk through the plaster and lath.

3. Impact Load

Partition specimen *BZ–I1* during the impact test is shown in figure 32. The results for specimens *BZ–I1*, *I2*, and *I3* under impact load are given in tables 12 and 13 and in figure 33.

Table 13.—*Effects of impact load on partition BZ*

Description of effects	Specimen *I1*		Specimen *I2*		Specimen *I3*	
	Height of drop	Deflection	Height of drop	Deflection	Height of drop	Deflection
Plaster, first cracks:	*ft.*	*in.*	*ft.*	*in.*	*ft.*	*in.*
Face loaded	1.0	0.45	1.0	0.51	2.0	0.76
Face not loaded	2.0	.70	.0	.00	2.5	.89
Failure of face by spalling of plaster at cracks:						
Face loaded	4.0	1.24	4.0	1.31	4.0	1.24
Face not loaded	4.0	1.24	4.5	1.50	4.5	1.41
Face loaded, lath broken by sandbag	4.5	1.33	4.0	1.31	6.5	1.98
Center stud:						
First crack	10.0	3.02	6.0	3.14	8.5	3.72
Rupture, sandbag passing through specimen			7.5			

The impact loads were applied to the center of one face of each specimen, the sandbag striking the plaster directly over the center stud. The effects are described in table 13.

After the 10-ft drop on specimens *I1* and *I3* the sets were 0.39 and 4.00 in., respectively. The lath on the face not loaded was separated from the studs at midspan.

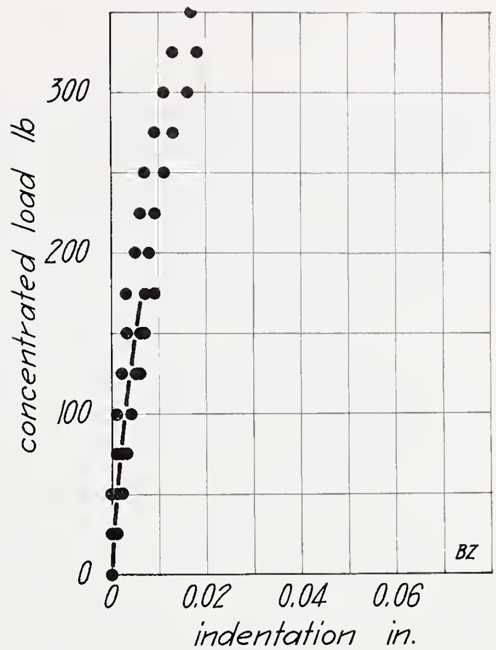

Figure 31.—*Concentrated load on partition BZ.*

Load-indentation results for specimens *BZ-P1*, *P2* and *P3*.

VIII. PARTITION *CA*

1. Sponsor's Statement

Partition *CA* was a wood frame construction with "Celotex" building board as both faces. The frame was similar to that of walls *BX* and *BY* and of partition *BZ*, and both faces were similar to the inside face of wall *BY*.

The price of this construction in Washington, D. C., as of July 1937, was \$0.36/ft².

The partition specimens in figure 34 were 8 ft 0 in. high, 4 ft 0 in. wide, and 4⅝ in. thick; and consisted of a frame of three studs, *A*, fastened to a floor plate, *B*, and a top plate, *C*, by nails, with building board, *D*, as both faces. The specimens were not painted.

Studs.—The studs, *A*, were Douglas fir, 1⅝ by 3⅝ in. (nominal 2 by 4 in.) by 7 ft 7⅛ in., S4S (surfaced four sides), spaced 1 ft 4 in. on centers, and toenailed to the plates with 8d common wire nails, five to each end, two

through each side, and one through one edge of the stud.

Floor plate.—The floor plate, *B*, was Douglas fir, 1⅝ by 3⅝ in. (nominal 2 by 4 in.) by 4 ft 0 in., S4S.

Top plate.—The top plate, *C*, consisted of two pieces of Douglas fir, 1⅝ by 3⅝ in. (nominal 2 by 4 in.) by 4 ft 0 in., S4S, fastened together by six 16d common wire nails driven from the top of the upper member of the plate, two at each stud.

Building board.—The building board, *D*, was 8 ft 0 in. long, 4 ft 0 in. wide, and ½ in. thick, fastened to the wood frame by 1¼-in. wire brads spaced 6 in. along studs and 3 in. along both plates.

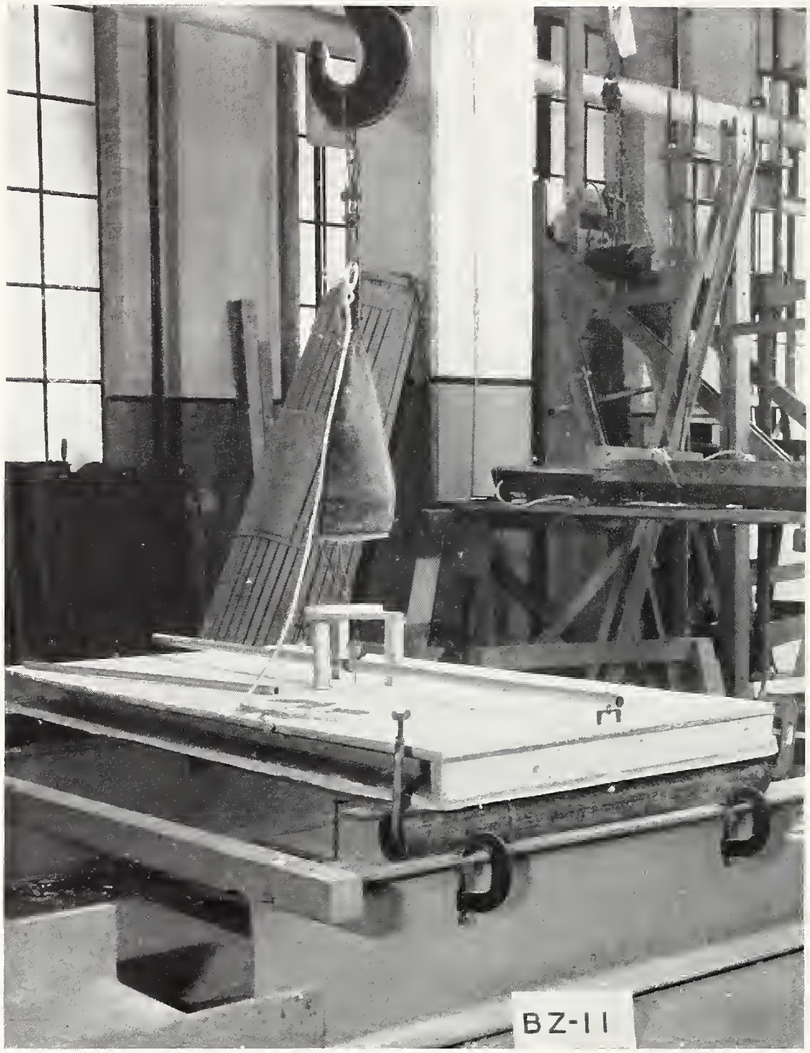

FIGURE 32.—*Partition specimen BZ–I1 during the impact test.*

2. Concentrated Load

Partition specimen *CA–P3* under concentrated load is shown in figure 35. The results for specimens *CA–P1*, *P2*, and *P3* are given in table 12 and in figure 36.

The concentrated loads were applied on the building board midway between two studs, approximately 2 feet from one end. At the maximum load failure occurred by punching of the disk through the building board.

3. Impact Load

The results for partition specimens *CA–I1*, *I2*, and *I3* under impact load are shown in tables 12 and 14 and in figure 37.

The impact loads were applied to the center of one face of each specimen, the sandbag striking the building board directly over the center stud. The effects are given in table 14.

Table 14.—*Effects of impact load on partition CA*

Description of effects	Specimen *I1*		Specimen *I2*		Specimen *I3*	
	Height of drop	Deflection	Height of drop	Deflection	Height of drop	Deflection
	ft	*in.*	*ft*	*in.*	*ft*	*in.*
Face loaded:						
Cracked under sandbag	2.5	1.47	3.5	1.78	3.0	1.78
Failure by rupture of building board where sandbag struck	3.0	1.60	5.5	2.20	5.0	2.29
Face not loaded:						
Separated from studs	5.5	2.22	4.5	2.08	4.5	2.11
Failure by transverse rupture of building board	8.0	------	------	------	7.5	5.81
Center stud:						
First crack	6.0	2.70	9.5	3.43	7.5	5.81
Rupture, sandbag passing through specimen	8.0	------	------	------	8.0	------

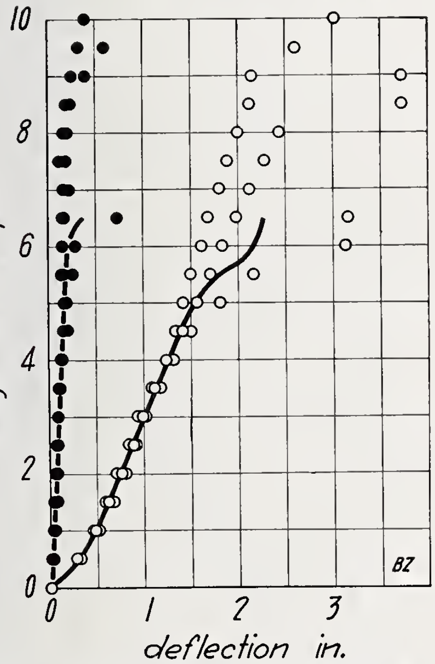

Figure 33.—*Impact load on partition BZ.*

Height of drop-deflection (open circles) and height of drop-set (solid circles) for specimens *BZ—I1*, *I2*, and *I3* on the span 7 ft 6 in.

After the 10-ft drop on specimen *I2* the set was 0.77 in., and no further effects were observed.

IX. SPONSOR'S COMMENTS

The specimens submitted by the sponsor are representative of conventional wood-frame con-

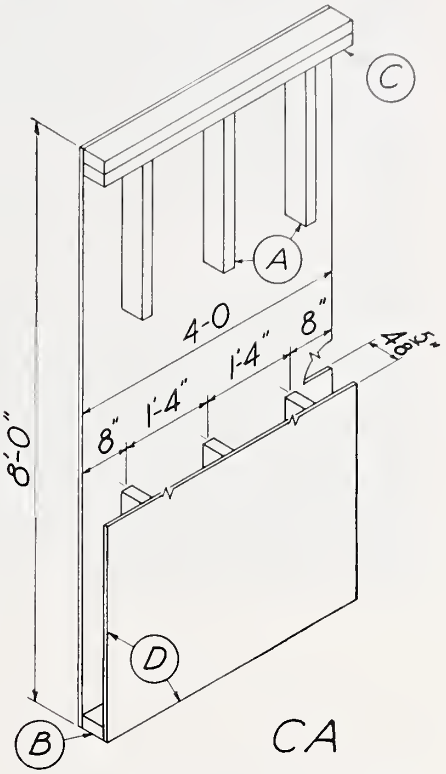

Figure 34.—*Partition specimen CA.*

A, stud; *B*, floor plate; *C*, top plate; *D*, building board.

struction. The asphalt-coated sheathing in constructions *BX* and *BY* serves as thermal insulation and also resists the passage of moisture from the outside.

The inside face may be finished with either of two materials. "Celotex Vapor-seal" lath provides a plaster base, adds structural strength, and resists the passage of moisture from the inside face of the wall to the spaces between the studs. "Celotex" building board adds strength to the structure and presents a durable and pleasing interior finish.

The physical properties of the three "Celotex" products described in this report are given in table 15. These data were obtained August 1, 1939, in accordance with the sampling procedure and test methods of Federal Specification LLL–F–321a, Fiberboard; Insulating, and may be taken as representative of current manufacture.

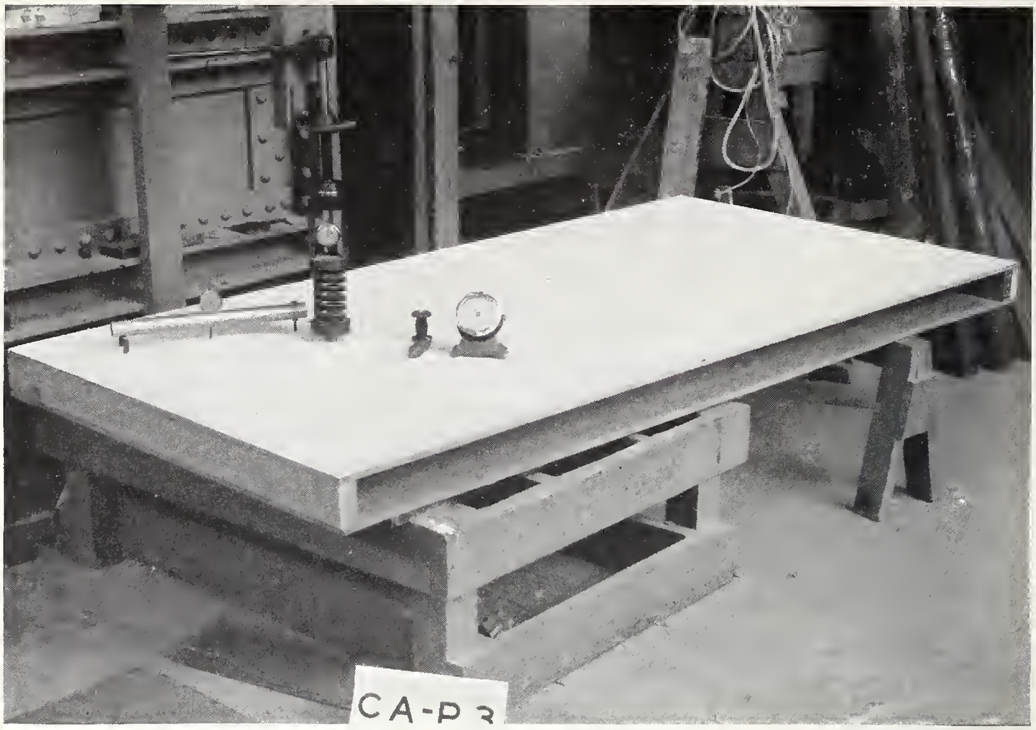

Figure 35.—*Partition specimen CA–P3 under concentrated load.*

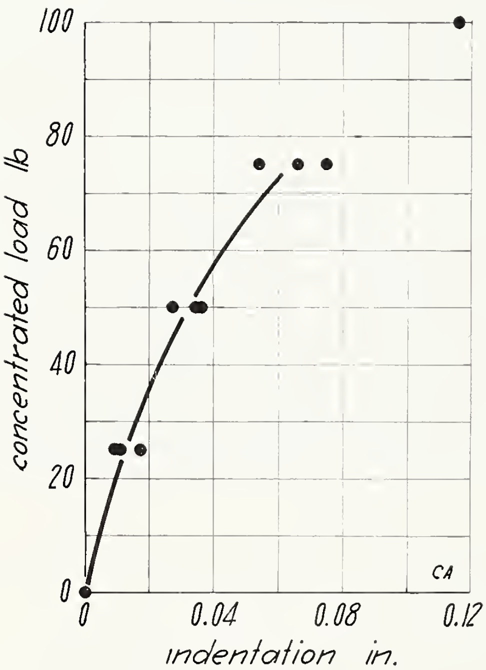

Figure 36.—*Concentrated load on partition CA.*

Load-indentation results for specimens *CA–P1*, *P2*, and *P3*.

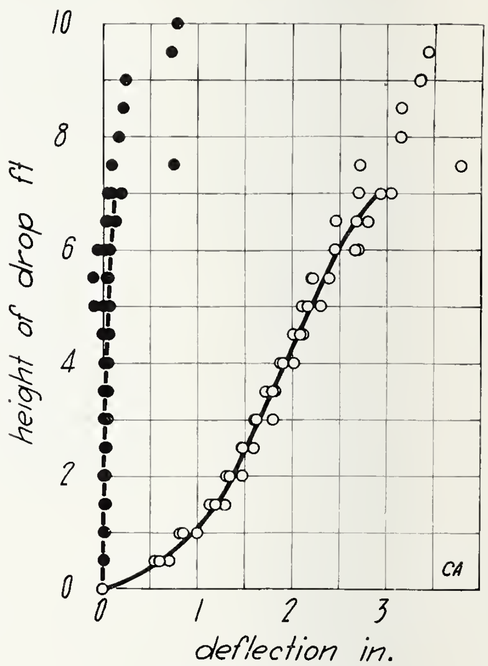

Figure 37.—*Impact load on partition CA.*

Height of drop-deflection (open circles) and height of drop-set (solid circles) for specimens *CA–I1*, *I2*, and *I3* on the span 7 ft 6 in.

Table 15.—*Physical properties of building board, sheathing, and lath*

[Samples obtained and tested by R. W. Hunt Co., engineers, in accordance with Federal Specification LLL-F-321a]

Insulating board	Thickness	Transverse test				Tensile strength	Linear expansion for 47-percent relative-humidity change	Water absorption
		Strength		Deflection at ultimate load				
		Across long direction [a]	Across short direction [b]	Maximum	Minimum			
	Inch	*Pounds*	*Pounds*	*Inch*	*Inch*	*Pound/inches* ^{2}	*Percent*	*Percent*
"Celotex" building board	½	18.8	13.5	0.82	0.60	240	0.15	4.23
"Celotex Vapor-seal Insulating" sheathing	25/32	37.6	36.8	.50	.38	182	.10	2.64
"Celotex Vapor-seal Insulating" lath	½	18.6	16.4	.82	.79	337.5	.15	4.92

[a] The samples were cut lengthwise of the board.

[b] The samples were cut crosswise of the board.

The physical properties of the plaster were determined by the Lime and Gypsum Section of this Bureau, under the supervision of L. S. Wells, with the assistance of W. F. Clark. The physical properties of the building board, lath, and sheathing were determined by the Paper Section, under the supervision of B. W. Scribner, with the assistance of S. G. Weissberg.

The description and drawings of the specimens were prepared by E. J. Schell, G. W. Shaw, and T. J. Hanley of the Building Practice and Specifications Section, under the supervision of V. B. Phelan.

The structural properties were determined by the Engineering Mechanics Section, under the supervision of H. L. Whittemore and A. H. Stang, with the assistance of the following members of the professional staff: F. Cardile, H. Dollar, M. Dubin, A. H. Easton, A. S. Endler, M. Greenspan, C. D. Johnson, A. J. Sussman, and L. R. Sweetman.

Washington, August 25, 1939.

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